Final Report of the
UGC sponsored Major Research Project on

"Impact of developmental interventions on algal diversity in Deepor beel- a Ramsar site"

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Executive Summary

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Introduction

Algae play a fundamental role in determining water chemistry, productivity, regulation of food chain. They serve as the primary source of energy and oxygenate the ecosystem through the process of photosynthesis.

Algae are known to exhibit an extent of constancy in their periodicity and succession in relation to cyclic change of environmental factors in any water bodies (Palmer, 1967). Algae are thus, considered to be the foremost organisms that respond to environmental changes and nutrient fluctuation. Different groups of algae require different range of temperature, organic matter, pH, dissolved oxygen and they are seen to be present only when the suitable ranges of these parameters are available. (Chapman and Chapman, 1960). Thus, they serve as biological indicators of organic water quality, and/or the extent of nutrient enrichment of any aquatic body (Venkataraman, 2002)

Considering the ecological importance of algae, important studies regarding algal diversity in relation to water quality was done across the globe (Ariyadej *et al.,* 2004; Shekhar *et al.,* 2008; Barinova *et al.,* 2010; Dogiparti *et al,* 2013). Unfortunately, very little work could be encountered on the status of phytoplankton in polluted environment in different freshwater bodies of Assam (Baruah and Bordoloi 1988, 1990; Bordoloi and Baruah, 2014).

Assam is one of the mega states of the North East India and is blessed with a wetland of international accreditation. It is the Deepor Beel, the only Ramsar Site in Assam. Deepor Beel was designated as a Ramsar Site in 2002 as site No. 1207. It is the abode of several rare and endangered flora and fauna. This wetland contains rich amount of organic carbon, available nitrogen and phosphorous (Saikia, 2013) and thus, it serves as a breeding and feeding ground for innumerable number of migratory birds. The wetland provides habitat to several globally threatened bird species including the Great Adjutant Stork, White Rumped Vulture , Long – billed vulture, Spot billed pelican, Baer's Pochard etc. Due to these reasons, a part of the beel has been declared as a bird sanctuary. The beel not only houses migratory and residential water fowls, but also are the home of endangered animals such as the Asiatic elephant, jungle cat, barking deer, Sambar, and a breeding ground of many native fishes as well as threatened reptiles and amphibians (Goswami and Kalita, 2012).

The Deepor beel which is considered as the major water storage basin of Guwahati city harbours rich phytoplankton diversity. Phytoplankton, functioning as the primary producers, forms the integral part of any aquatic ecosystem. They are the most important constituents of food web and contribute significantly to the biological productivity. Algae serve as the food for several fishes and perform the critical function of maintaining balance of the aquatic ecosystem like Deepor beel. Thus, they occupy an important position in the biological composition of this wetland of international repute.

Recently Deepor beel is facing severe challenge due to natural and manmade anthropogenic activities. Rapid multiplication of industries and estates as well as human settlements around the beel is posing threat to this aesthetically beautiful wetland. The encroachment of the beel is evident by the presence of a number of cement structures around the area of this natural water basin. The laying of railway tracts has caused rapid shrinkage of the beel area. A number of brick kilns have also been established in and around the vicinity of the beel which is responsible for pollution and creation of an unhealthy environment. Man has turned such a unique habitat blessed with rich biodiversity into a noxious spot of garbage dumping. The solid and liquid wastes leaching into the water body deteriorates its water quality thereby affecting the biotic composition therein including the algae. Heavy deposition of nutrients has lead to eutrophication of the beel and has favoured not only the growth of a wide range of aquatic macrophytes and microphytes, but also has dictated the change in botanical composition. Hence it needs exclusive and in depth study on water quality and related biological composition of the beel.

The impact of developmental interventions on algal flora of Deepor beel is one of the almost virgin topics on which very meager and insufficient works have so far been reported. Since algae occupy the basic and lowermost level of the food chain, their conservation will lead to the conservation of entire biotic community of the beel. The present work has therefore, been undertaken to assess the impact of developmental interventions on the algal flora of Deepor beel with the following objectives-

1. To inventorise and document the existing algal diversity in and around Deepor beel.
2. To study the periodicity and seasonal dynamics of algal population in Deepor beel.

3. To assess the physico-chemical constituents of water in Deepor beel in relation to developmental interventions.
4. To assess the impact of developmental interventions on algal diversity.

Material and Methods

To meet the objectives of the present endeavour, we designed an ecological work in the Deepor beel. Accordingly water and algal samples were collected from five different sampling sites of the beel at regular intervals of one month from September, 2011 to August, 2013. The GPS co-ordinates and location characteristics of the five different sites chosen for the study are mentioned below-

Study Sites	**Latitude**	**Longitude**	**Important Features**
Site 1	26^0 07' 35"	91^0 37' 57"	Within the jurisdiction of Deepor beel Wild Life Sanctuary
Site 2	26^0 08' 22"	91^0 38' 27"	In the midst of industrial activities
Site 3	26^0 07' 06"	91^0 39' 21"	Near to Deepor beel wildlife sanctuary close to the point of fishing activities
Site 4	26^0 06' 52"	91^0 40' 13"	Near the municipality garbage dump ground
Site 5	26^0 06' 31"	91^0 37' 32"	Near to the railway line

Samples were collected from different points in each sampling site and were stored in two liter sterilized bottles previously rinsed with the beel water. The water samples were then brought to the laboratory for the estimation of physico-chemical parameters. The physico-chemical properties of water samples were estimated by standard methods as proposed by APHA (2012) and Trivedy and Goel (1986). Proper identification of the observed algal samples were done by following relevant literatures and standard monographs by Desikachary (1959), Chapman and Chapman (1962), Prescott (1969), Perumal and Anand (2009), Yamagishi (2010). CCA analysis was carried out to explain the relationship between the algal divisions with the changing water chemistry along the changing seasons in the five different study sites of Deepor

beel. This analysis was carried out with the help of PAST software taking the densities of the algal species belongs to each group into consideration.

Results and Discussion

Algal Composition

Altogether, 257 algal species under 66 genera belonging to 5 different taxonomic groups viz. Cyanophyceae, Chlorophyceae, Bacilariophyceae Euglenophyceae and Xanthophyceae were recorded from five different sites of the Beel. Bacilariophyceae was found to be the most dominating group comprising of 97 species followed by chlorophyceae with 83 species. Cyanophyceae occupied the third position with 66 species and with 10 species, Euglenophyceae stood in fourth position. There was only one species belongs to Xanthophyceae in the study sites of the beel.

The present ecological investigation has brought into limelight that Deepor beel was very rich in algal diversity. The composition of algae was extensively monitored along five different sites of Deepor beel which were selected based on extent of developmental interventions and the results can be best illustrated with the help of a graph given below (Fig- 1)

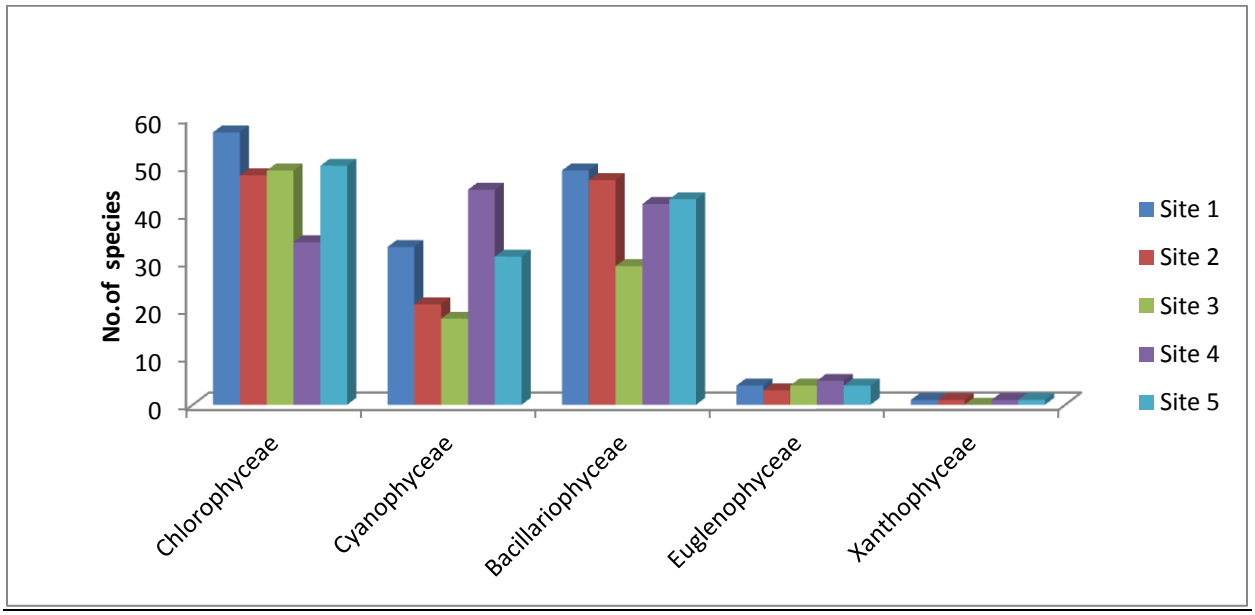

Fig- 1: Algal composition along five different sites of Deepor beel

Percentage composition of algae

During the course of the study, the percentage of different groups of algae along five different study sites was calculated (Fig 2 to Fig 6) which revealed that the chlorophyceae formed the dominant group in majority of the study sites, including the first (39.58%), second (40%), third (49%) and the fifth (38.46%), whereas in the fourth site cyanophycean algae (35.43%) were outnumbered in comparison to others..

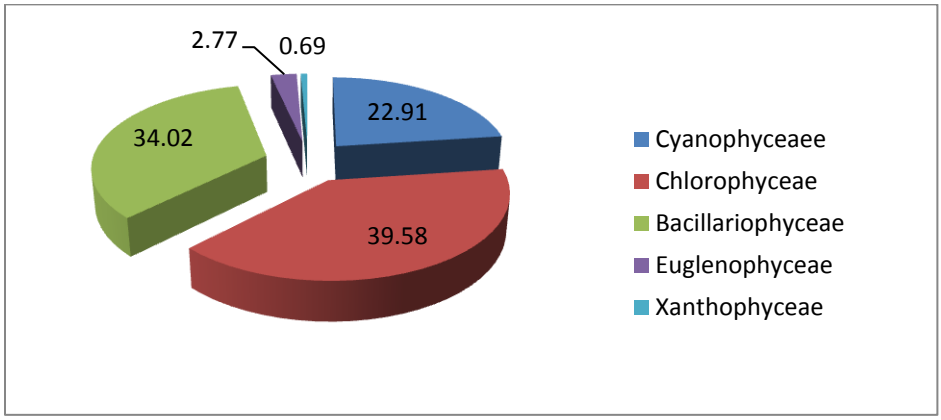

Fig 2: Percentage composition of Algal groups in Site 1

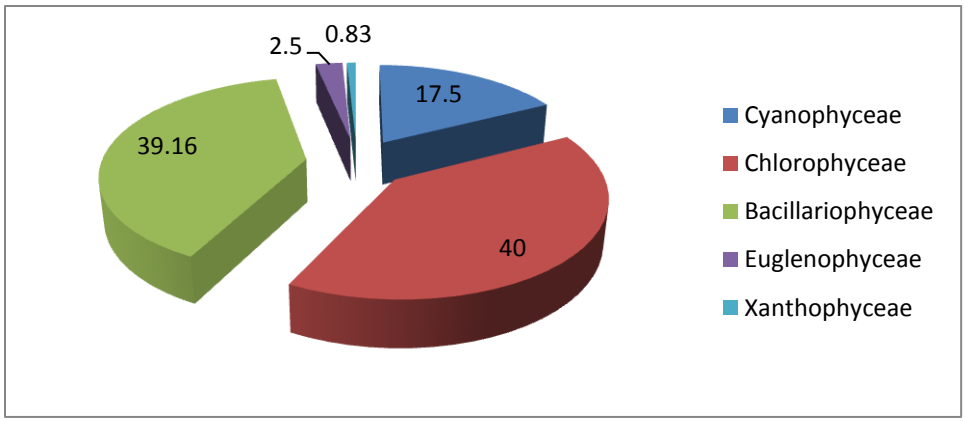

Fig 3: Percentage composition of Algal groups in Site 2

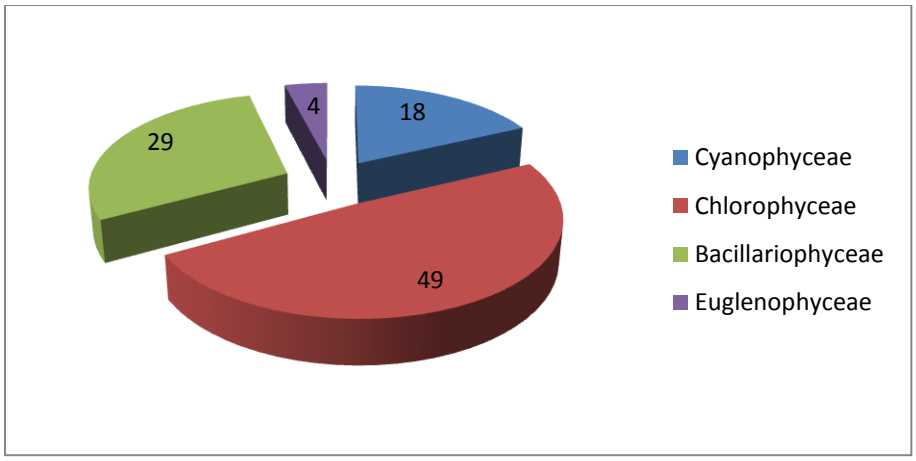

Fig 4: Percentage composition of Algal groups in Site 3

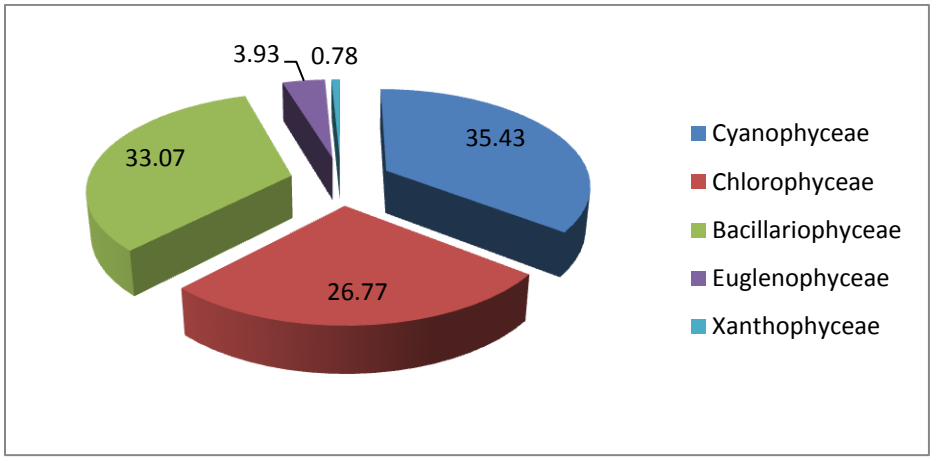

Fig 5: Percentage composition of Algal groups in Site 4

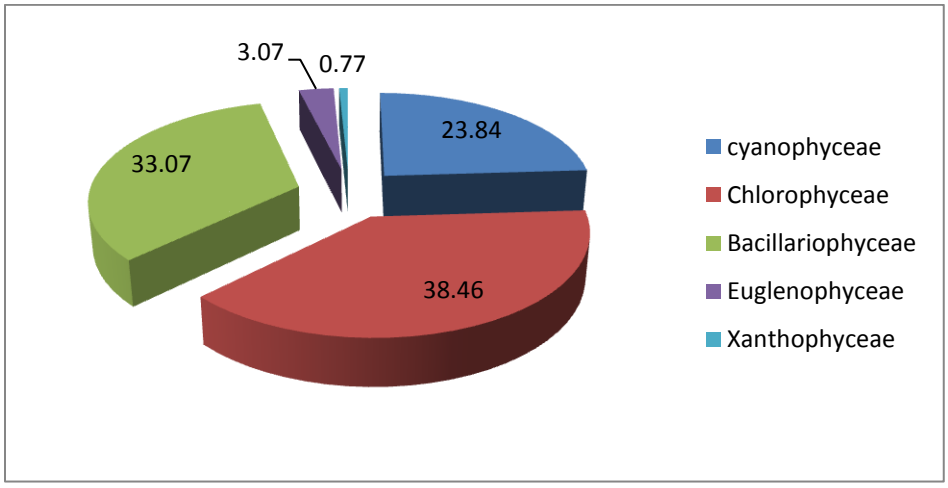

Fig 6: Percentage composition of Algal groups in Site 5

The higher composition of cyanophyceae in the fourth site indicates exceedingly alkaline and nutrient rich status of the study site, which was similar to the observations made by Nayak and Prasanna (2007) and Barinova *et al.,* (2010). The fourth study site, located near to the Municipality garbage dumping site experiences heavy load of organic pollution due to constant deposition of untreated sewage. Moreover, the increased presence of pollution tolerant genera such as *Scenedesmus, Microcystis, Nitzschia, and Euglena* reflected high degree of civic pollution in the fourth study site of Deepor beel.

Seasonal Variation in Algal composition

Algal species in Deepor beel was seen to exhibit pronounced seasonal variation. In the course of the present investigation, the seasonal distribution of algae along five different sites of Deepor beel had been extensively monitored during four distinct seasons of Assam viz. winter (mid November- February), pre-monsoon (early March – mid May), monsoon (mid May – mid September) and post monsoon (mid September – mid November). Subsequently, algal species present in the water body were placed into one of the four categories on the basis of their relative abundance: rare – algae comprising less than 1%; uncommon – algae comprising from 1 to 5%; common- algae comprising from 5 to 10%; abundant – algae occupying more than 10%

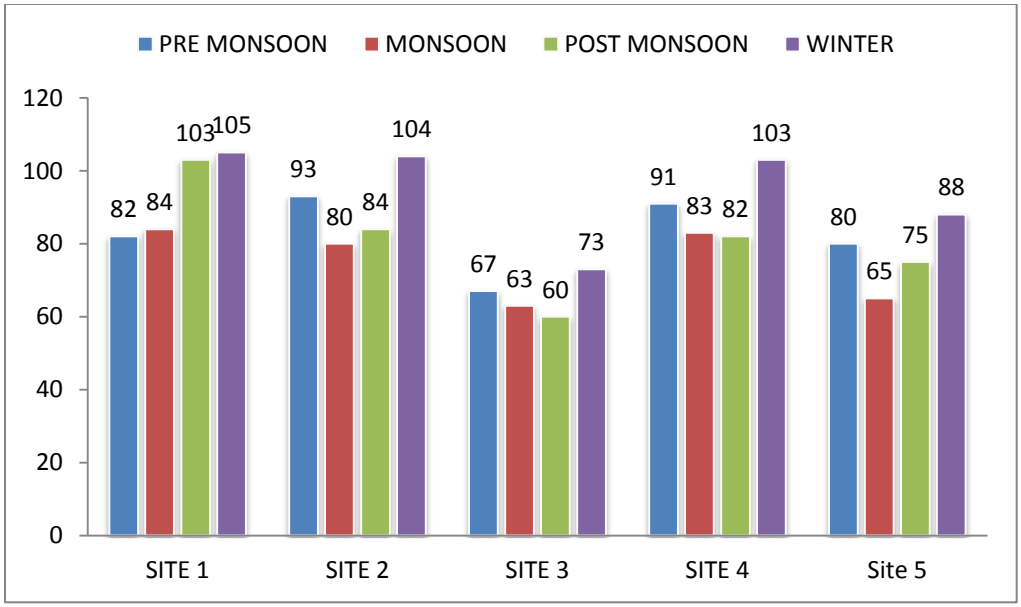

Fig 7: Species Composition of Algae during four seasons along five different sites

The present investigation (Fig 7) has brought into limelight that, highest numbers of algal species were present in all the study sites during winter whereas that of lowest during pre monsoon season in Site 1, during post monsoon in the third and fourth sites and during monsoon in the second and fifth study sites. This variation in algal species composition may be credited to the varying hydrochemistry in the five different study sites in relation to intermittent rain as well as of flood.

Algal Density

Algal density was estimated in Deepor beel by using Sedgwick rafter counting cell. This parameter was seen to possess distinctive variation during different seasons along different sites. The variation of algal densities along five different sites during the four seasons can be illustrated graphically as below-

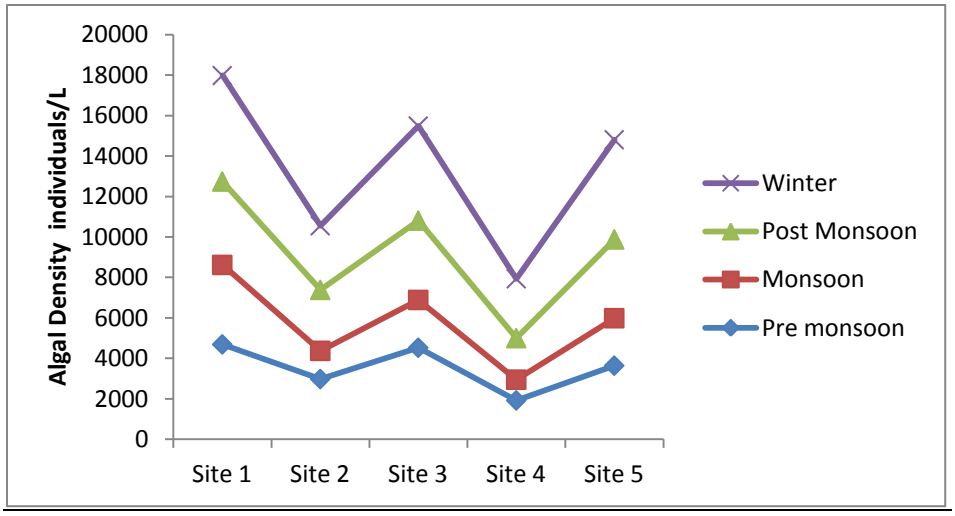

Fig 8: Variation of algal density during four seasons along five different sites

During the present investigation, Site 1 which was located within the jurisdiction of the Deepor beel Wildlife Sanctuary was seen to possess higher algal density in comparison to other sites (Fig 8). Again, the fourth study site located near to the municipality garbage dump possessed the lowest density of algae.

CCA analysis

Canonical correspondence analysis (CCA) was employed to detect the relationship between the physico chemical variables along the changing seasons with the density of five different algal groups present in the Deepor beel.

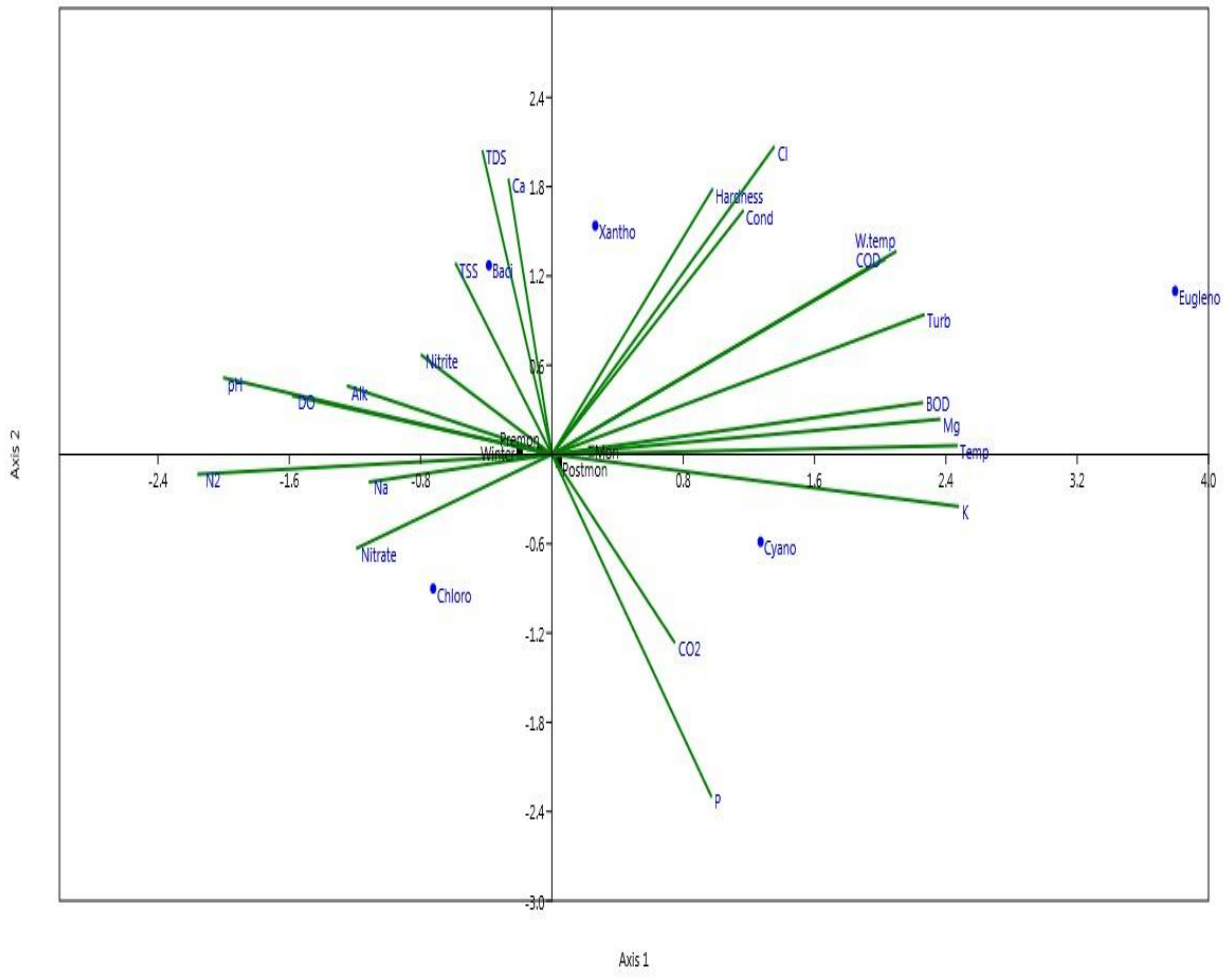

Fig 9: CCA plot showing relationship of algal divisions with the physico chemical attributes along different seasons in Site 1 of Deepor beel.

It is clear from the fig 9 that the cyanophycean and xanthophycean algal members were found abundantly during the monsoon and postmonsoon seasons when the water temperature, BOD, COD, turbidity, hardness, Cl, Mg, K, P, free CO_2 was comparatively higher.

On the contrary, the chlorophyceae and the bacillariophyceae were present excessively during the colder winter and premonsoon when temperature as well as other nutrients was comparatively lower and dissolved oxygen was high. Chlorophyceae had relatively higher density in winter. Again, cyanophyceae showed higher density in monsoon and post monsoon. This may be attributed to the higher values of temperature, turbidity and phosphates during the period which favours the luxuriant growth of the cyanophyceae which is in conformity with the results of Kavitha and Balasingh (2007). Bacillariophycean diversity was higher during post monsoon and winter, which may be related to low temperature (Bhat, 2012), high values of nitrogen and low values of phosphate (Tilman *et al.*, 1986).

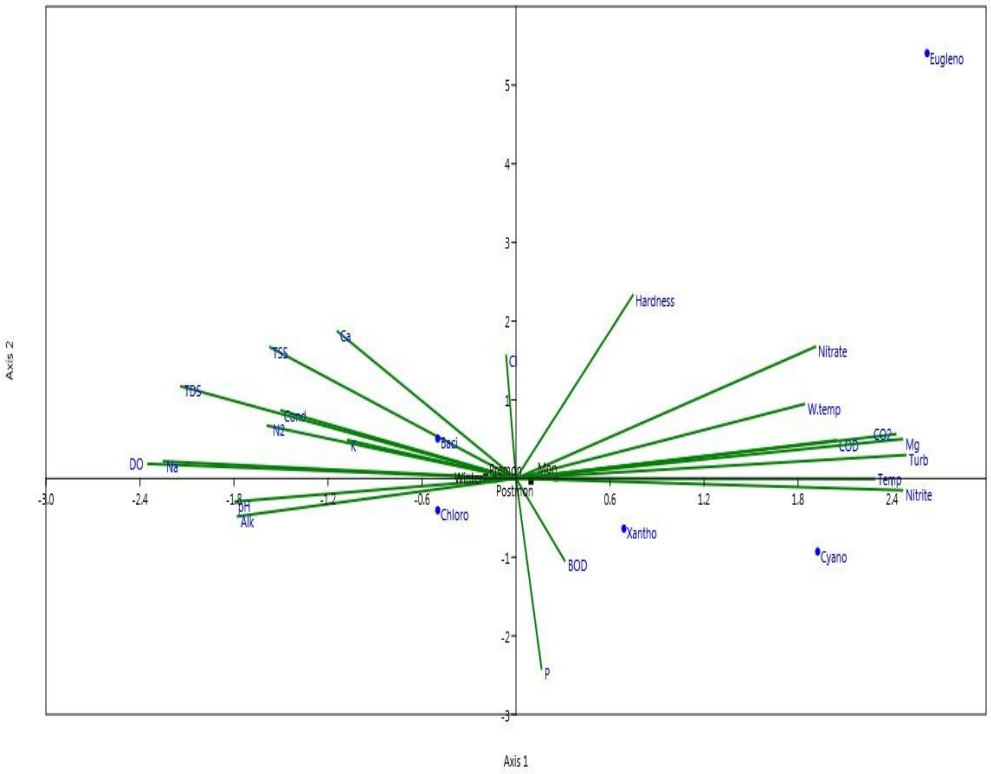

Fig 10. CCA plot showing relationship of algal divisions with the physico chemical attributes along different seasons in Site 2 of Deepor beel.

In this site also, the chlorophyceae and the diatoms were dominant during winter and premonsoon, while the cyanophycean members during the monsoon and post monsoon. This may eventually be attributed to the low temperature and nutrients in winter and higher values of

temperature, turbidity and phosphates in the monsoon and post monsoon (Kavitha and Balasingh, 2007; Jemi and Balasingh , 2011).

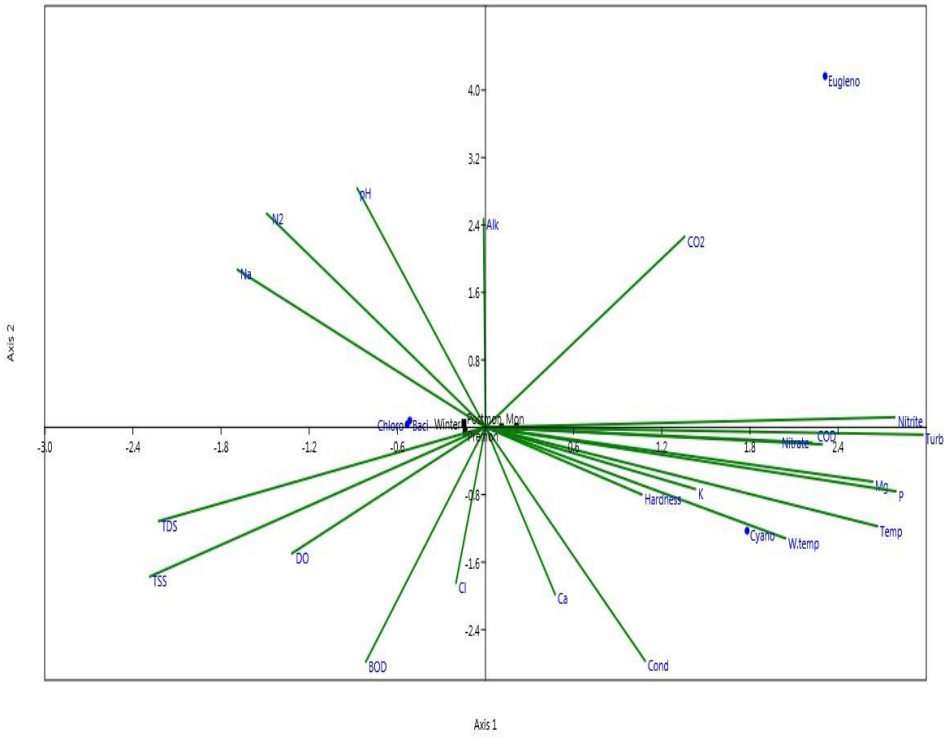

Fig 11. CCA plot showing relationship of algal divisions with the physico chemical attributes along different seasons in Site 3 of Deepor beel.

In the third site, chlorophyceae and bacillariophyceae showed higher density during winter, while cyanophyceae during monsoon. Higher concentration of nutrients such as phosphates, Ca, Mg, accompanied with elevated water temperature may be accountable for the increased density of cyanophyceae during monsoon, while lower values of the same along with higher dissolved oxygen favoured the luxuriant growth of chlorophyceae during winter (Verma and Mohanty, 1995; Nayak and Prasanna, 2007).

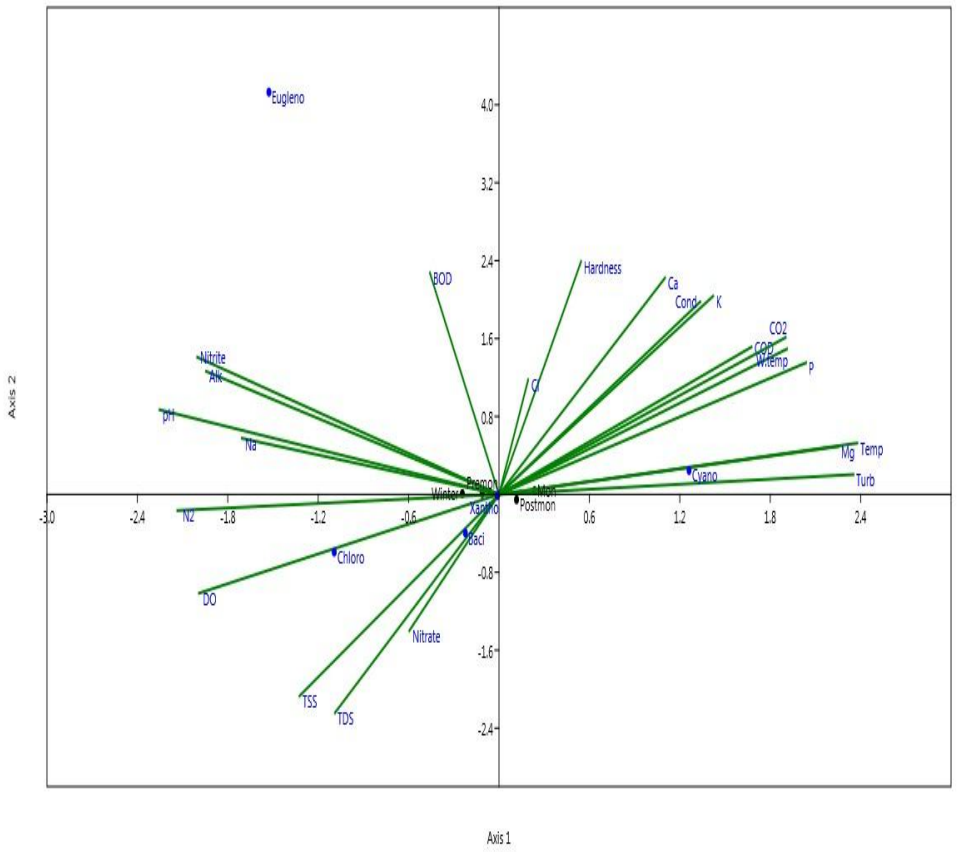

Fig 12. CCA plot showing relationship of algal divisions with the physico chemical attributes along different seasons in Site 4 of Deepor beel.

As per our investigation, the fourth study site, which was located within the zone of the municipality city garbage dumping ground also showed higher density of cyanophycean members during monsoon as well as post monsoon when water temperature, turbidity, free CO2, nutrients such as Ca, Mg were considerably high. The green algal members and diatoms showed dominance during winter when dissolved oxygen and nitrogen content was high and other major nutrients were scanty which is in conformity with Kavitha and Balasingh (2007) and Hujare (2008).

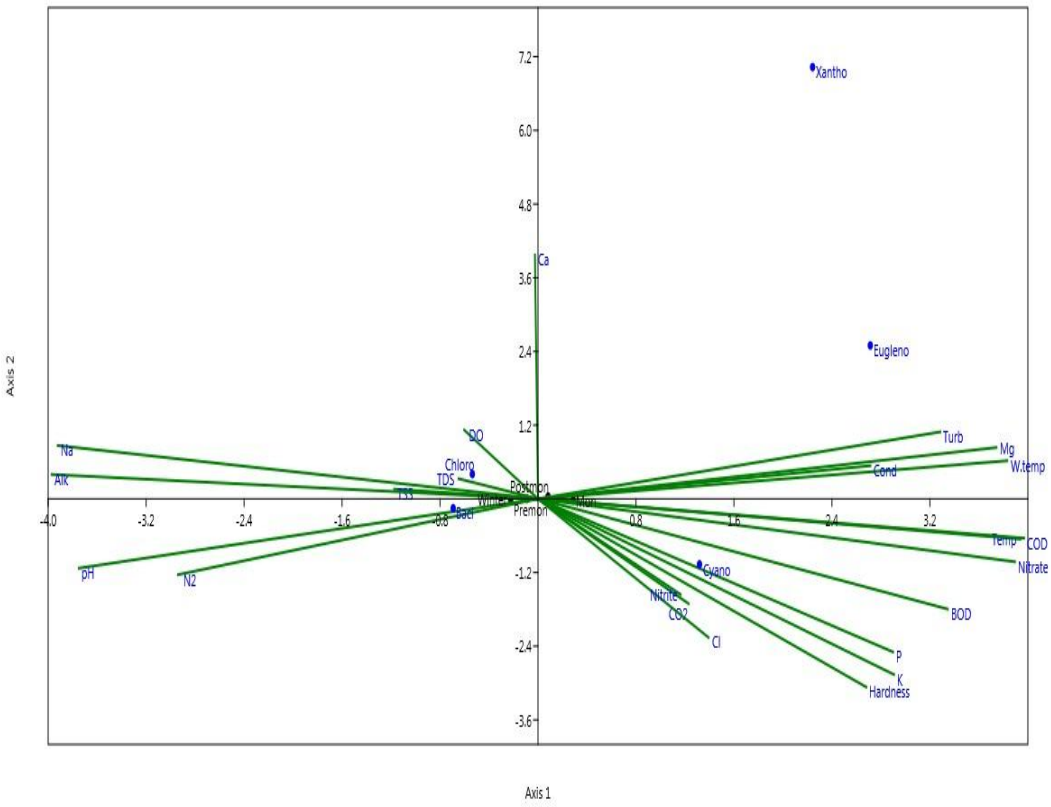

Fig 13. CCA plot showing relationship of algal divisions with the physico chemical attributes along different seasons in Site 5 of Deepor beel.

The present analysis on Site 5 revealed higher density of cyanophycean algae during the monsoon season, while, the green algal members together with the diatoms attained peak during winter, similar to the other four sites.

It may summarized that Cyanophyceae showed peak during monsoon and post monsoon, whereas chlorophyceae and bacillariophyceae attained with maximum density during winter and premonsoon in all the studied sites. Euglenophyceae and xanthophyceae were present with relatively smaller densities.

Species Diversity index and Evenness index

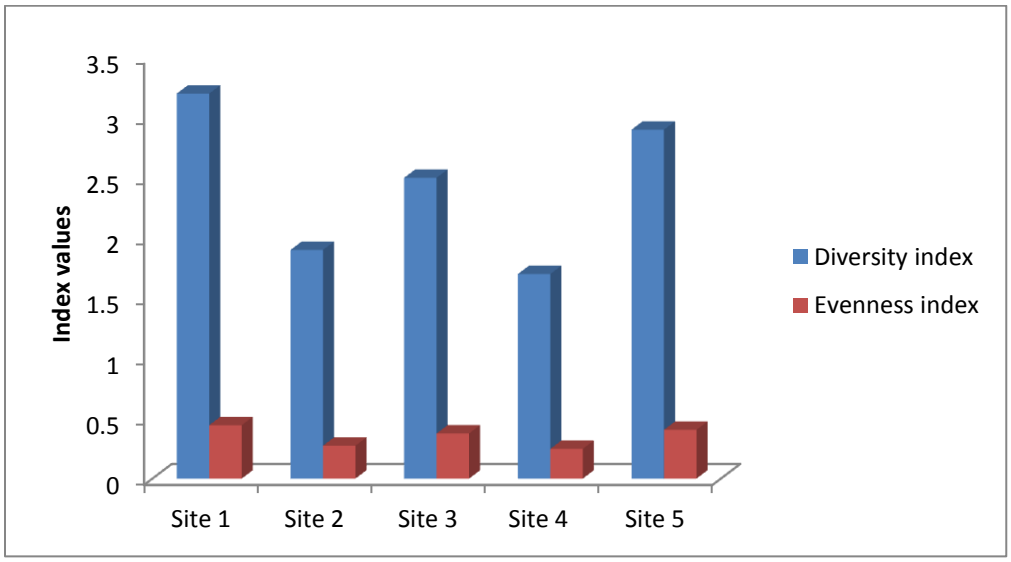

Fig 14: Variation of Diversity index and Evenness index along five different sites of Deepor beel

The study revealed that the first study site, located amidst the vicinity of the Deepor beel wildlife Sanctuary possessed the highest diversity index (3.2). On the contrary, the fourth study site, located near to the city garbage dumping area had the lowest values of diversity index (1.7). Species evenness index also showed similar patterns of variations. Its value was highest in Site 1(0.444) and lowest in Site 4 (0.274) just like the diversity index values. On the basis of diversity index values, Site 1 (3.2) could be given the status of being lightly polluted, while Site 2 (1.9), located near to several industries and Site 4 (1.7) i.e. the garbage dumping ground were heavily polluted. The third study site (2.5), located near the Deepor beel wildlife sanctuary close to the fishing activity point and the fifth site (2.9) situated nearby the railway tract were seen to possess moderate pollution. Site 1 having light pollution status, possessed comparatively cleaner water than the other four sites. As such, the value of species evenness was also highest there. It could therefore be concluded that, the first study site had high equality and homogeneity in its species composition than the other sites studied.

Palmer's values

During our present course of study, a good number of pollution tolerant genera were recorded from the study area. This eventually necessitated the evaluation of the extent of pollution present in the water body. Palmer's pollution index value is a suitable parameter in assessing the degree of pollution in aquatic bodies.

Palmer's pollution index score revealed that, the fourth site of Deepor beel, located amidst the garbage dump area exhibited highest degree of pollution while, the first study site situated within the territory of the Deepor beel Wildlife Sanctuary was least in terms of organic pollution as per Palmer's value (28). Since Site 4 was located near the Guwahati municipality garbage dumping area, here the water body received continuous supply of sewage and other wastes in this particular point that eventually lead to extremely high organic pollution (35) . On the contrary, the first study site was located within the terrain of Deepor beel wildlife sanctuary, thereby experiencing least pollution.

Contribution to the society

Since algae are the donors to the water body and the indicators of wetland health, the present study has been initiating a new trend of research in monitoring and assessment of Deepor beel Ramsar site using algae. The outcome of the present endeavour will serve as a baseline database of algal ecology of Deepor beel which houses good number of fish, aquatic resident and migratory birds and the other ecological sensitive wetland macro and microorganisms. The present information is also suitable for sustainable food web management practices in the Deepor beel Ramsar site.

Recommendations

1. As the area under the Wildlife Sanctuary was comparatively cleaner, the Sanctuary boundary may be extended.
2. As the biggest threat to the beel is the municipal corporation's garbage dumping station, it may be removed from the place.
3. Biomonitoring with the Palmer's algal pollution indicators may be initiated in each and every corners of the beel on regular basis.

Acknowledgement

I am thankful to the UGC, New Delhi for the financial support. I extend my special appreciation to the local inhabitants, boatmen and Forest personals of the periphery of the Deepor beel.

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